TECHNOLOGY BRIEF

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Compaq Computer Corporation

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Compaq ProLiant 8000 Server Technology

This technology brief describes the high-performance, high-availability, storage, and management technologies built into the Compaq ProLiant *8000 server. The high-performance technologies include a new 8-way system architecture driven by the Profusion chipset codeveloped by Compaq, Intel, and Corollary, as well as Intel's Pentium III Xeon processors. In addition, new disk drive technology and a new extended SCSI controller with redundancy capability allows the* ProLiant *8000 server to deliver maximum highly available internal storage capacity.*

The high-availability technologies include redundant internal array controllers; PCI Hot Plug technology; redundant hot-plug power supplies, drives, and fans; and redundant processor power modules. The ProLiant *8000 design also contains easy-access components that reduce downtime for service or upgrades. Key management technologies, such as the Integrated Remote Console, Integrated Management Display, Remote-flash Redundant ROM, and auto-default ROM configuration, further enhance availability.*

The intended audience for this paper is engineers and system administrators familiar with existing Compaq technology and servers. For those less familiar with Compaq technology, please see the related technology briefs referenced in this document. For more information about the ProLiant *8000 server, see the complete list of features at http://www.compaq.com/products/servers/ProLiant8000/quickspecs.html.*

COMPAQ

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Compaq ProLiant 8000 Server Technology

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INTRODUCTION

In today's business environment, enterprise customers require powerful servers with fault-tolerant features to keep their businesses running 24 hours a day, 7 days a week. They also need servers that are easy to manage and will scale to meet future requirements.

PCI – peripheral component interconnect

SCSI – small computer system interface

ROM – read only memory

Providing breakthrough performance, the *ProLiant* 8000 server offers outstanding scalability from one to eight Intel Pentium III Xeon processors, up to 16 GB of synchronous dynamic random access memory (SDRAM), and 11 PCI slots. The *ProLiant* 8000 server delivers massive internal storage, with capacity for more than 380 GB of internal Wide Ultra-3 SCSI hot-plug storage. A new extended SCSI array controller provides cable-free connections to the drive cages and allows all three drive cages to be configured as a single contiguous array or as separate arrays. High-availability features, including optional redundant array controllers, push-button PCI Hot Plug, hot-plug redundant fans, redundant hot-plug power supplies, Compaq Remote-flash Redundant ROM, and redundant processor power modules (PPMs), keep the *ProLiant* 8000 server up and running in the most demanding 7x24 environments.

The *ProLiant* 8000 server provides all of the high-availability and manageability features of the *ProLiant* 7000 server with added performance and scalability—all in a similar price class. In addition, Compaq delivers on its commitment to superior investment protection by offering a *ProLiant* 7000 in-chassis upgrade to 8-way architecture. Customers can leverage their *ProLiant* 7000 investment by keeping the chassis and serial number and replacing only select components for the upgrade. For more information, see the 8-way upgrade website at http://www.compaq.com/upgrade/8-way.

This technology brief explains the features of the *ProLiant* 8000 server and describes the management and storage technologies that enhance performance and availability. Many of these technologies are covered in more detail in separate technology briefs, which are referenced in this document.

HIGH-PERFORMANCE TECHNOLOGIES

The *Compaq ProLiant* 8000 server is a powerful, industry-leading technology solution for distributed enterprise computing. A revolutionary new 8-way system architecture allows the *ProLiant* 8000 server to deliver unsurpassed performance. This new architecture is the first implementation in the industry of the Profusion chipset and features Pentium III Xeon processors. Compaq servers using this architecture provide new levels of performance without requiring modifications or special releases of operating systems (OSs) or applications. The Compaq 8-way architecture provides nearly linear scalability for up to eight processors running under Microsoft Windows NT 4.0, Microsoft Windows 2000, Novell NetWare, or SCO UnixWare. The 8-way architecture delivers superior performance and price:performance for processor-intensive applications such as Microsoft Terminal Server and Oracle databases; for memory-intensive applications such as Lotus Notes, Microsoft Exchange, and SAP solutions; and for input/output (I/O) intensive applications such as Microsoft SQL Server.

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ProLiant 8000 Architecture

The system architecture is the key to the bigh level of performance offered by tbe *ProLiant* 8000 server. Compaq worked closely with Intel and Corollary for three years to perfect the 8-way symmetric multiprocessing (SMP) architecture so that the processors, memory, and I/O subsystem work in harmony to deliver breakthrough levels of performance. Figure 1 illustrates the architecture used in the *ProLiant* 8000 server. The essential features of the architecture include:

- Profusion five-point crossbar switch
- Dual 100-MHz processor buses
- Dual 100-MHz memory buses, each with its own memory controller
- Dedicated 100-MHz I/O bus
- Support for up to eight Pentium III Xeon processors
- Support for up to 16 GB of two-way, cache-line interleaved SDRAM
- Dual cache accelerators
- I/O filter
- Three Compaq designed host-to-PCI bridges

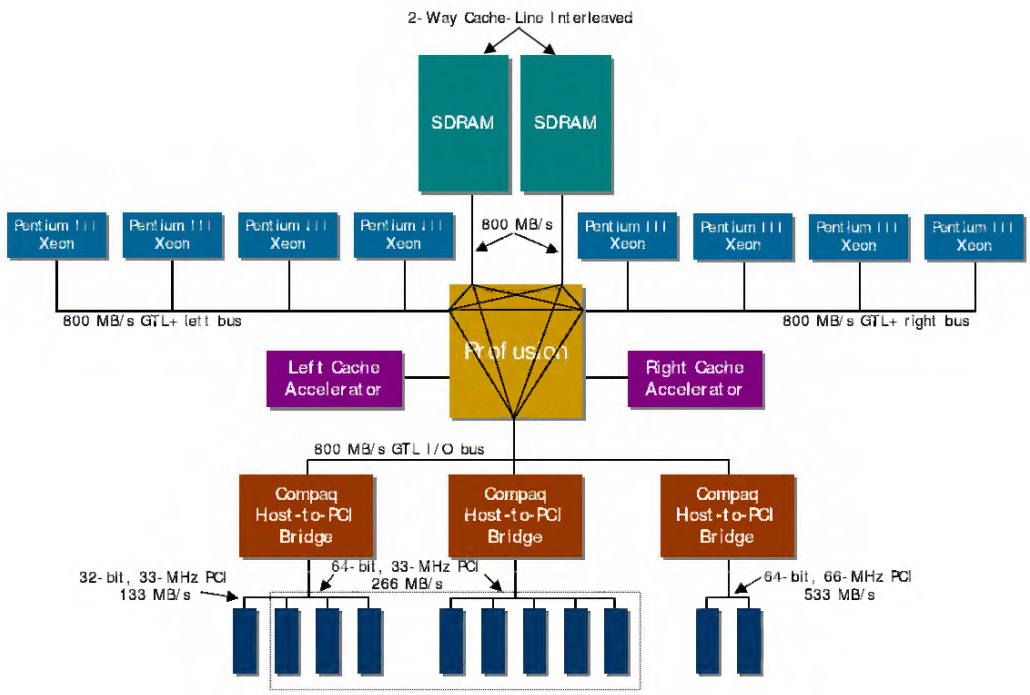

Figure 1: Block diagram of the ProLiant *8000 system architecture.*

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Profusion Chipset

At the heart of the 8-way architecture is the Profusion chipset. The chipset uses a five-point crossbar switch (Figure 2) to connect processor buses, memory ports, and the I/O bus. The crossbar switch contains static random access memory (SRAM) with ten ports—five read and five write—that appear as five bidirectional ports, one for each of the processor, memory, and I/O buses. The switch may connect two ports directly or may store data from tbe originating bus in the SRAM before it is transferred to the destination bus. This nonblocking design allows simultaneous read and write accesses from all five buses, which results in better system performance.

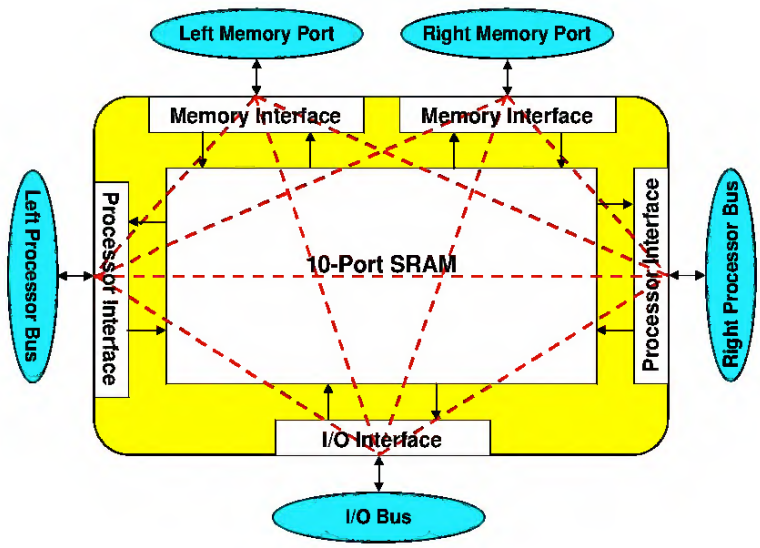

Figure 2: Block diagram of the Profusion crossbar switch.

The Profusion crossbar switcb provides direct patbs from each memory bus to eacb processor bus and to the I/O bus. Depending on the status of the system, the direct paths can be used to bypass the SRAM, thus reducing latency and improving performance. The direct paths are used only to read data. To improve processor utilization and performance, write data is always posted to the SRAM and written to main memory later.

The Profusion crossbar switch consists of two physical chips—the memory address controller (MAC) and the data interface buffer (DIB). This functional partitioning of the application-specific integrated circuit (ASIC), as shown in Figure 3, improves system performance. For every transaction from a processor or an I/O controller, the address and command portions are routed througb the MAC and the data is routed through the DIB. The MAC manages the external cache accelerators and tracks the information stored in the DIB. The DIB allows simultaneous data transfer on all five ports, has 64-cache-line buffers, and uses error-correcting code to maintain data integrity. The cache-line buffers can be used by any transaction for any device on any bus; and since there are no dedicated queues between buses, the efficiency of the buffers is high. This improves system performance.

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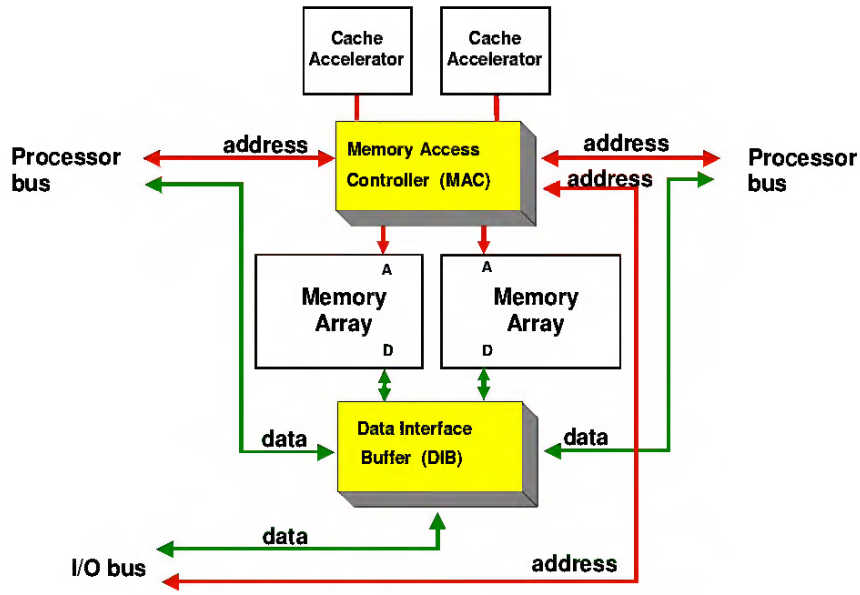

Figure 3: ASIC partitioning in the Profusion chipset.

Processor and I/O Buses

The *ProLiant* 8000 server includes two 64-bit processor buses and a dedicated 64-hit I/O bus. All three are 100-MHz advanced Gunning transceiver logic plus (AGTL+) buses with a theoretical maximum throughput of 800 MB/s. AGTL+ huses facilitate higher clock speeds without significantly reducing the bus length or number of electrical loads. Each 100-MHz AGTL+ bus can support a maximum of five loads per bus. This allows four processors and one connection to the memory controller on each processor hus. The use of two processor huses enahles the *ProLiant* 8000 server to support up to eight Pentium III Xeon processors.

The Profusion chipset joins the two processor buses, the I/O bus, and the two memory ports. The otherwise independent processor and I/O buses are joined by a logical connection that is made only when required to transfer data. Each of the three AGTL+ huses has independent access to the two memory ports. This architecture prevents I/O traffic from consuming handwidth on the processor bus. In addition, the use of 100-MHz huses and five independent paths allows the crosshar switch to deliver an aggregate instantaneous peak throughput of 4 GB/s—unprecedented high performance for customers.

Memory Subsystem

The *ProLiant* 8000 memory subsystem includes dual 100-MHz buses, each with its own memory controller. The use of two memory buses increases memory handwidth, reduces access conflicts, and increases the quantity of memory supported. Memory attached to each of the huses is cache-line interleaved, which means the huses share a common address range. One memory bus responds to even-numbered cache lines, and the other bus responds to odd-numhered cache lines. This configuration allows simultaneous use of hoth memory huses, which theoretically douhles throughput. It is especially advantageous for applications that access memory randomly. In random accesses, roughly half the requests at any one time are even-numbered lines, while the other half are odd-numbered lines.

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The memory subsystem uses uniform memory access, whicb reduces latency and gives all processors equal access times to either memory bus. In systems using nonuniform memory access architectures, a processor bas quick access to one memory bus but incurs a lag time (or latency) when accessing a second memory bus.

The *ProLiant* 8000 server supports up to 16 GB of error checking and correcting SDRAM that corrects all single-bit errors and detects double-bit errors. Memory is divided into eight banks, each consisting of two dual inline memory modules.

Although the Profusion chipset supports up to 32 GB of memory, industry-standard OSs provide only minimal support and scalability for tbis memory capacity, and enhanced support will not be available for an extended period. Also, in discussions with customers, Compaq learned that very few server implementations are fully configured with memory. With this in mind, Compaq used the internal server space to provide additional drive capacity in tbe *ProLiant* 8000 server. As customer requirements and OS capabilities increase in the future, Compaq will continue to modify servers to match these requirements.

Cache Accelerators

One of tbe main challenges of designing an efficient SMP architecture is maintaining cache coherency. To allow faster access to memory, most processors write data to cache memory rather than to main memory. When a processor writes data to its cache, the cache has a newer copy of the data than main memory. Cache coherency ensures that the most recent copy of the data is read by any device that requests it. The cache coherency protocol essentially makes the cache look like main memory. Cache coherency is critical for the proper operation of an SMP architecture, and the performance and scalability of the architecture is affected by how efficiently it maintains cache coherency.

With multiple processor buses and a separate I/O bus, it is extremely challenging to maintain cache coherency in the 8-way architecture. Each memory access must look at, or snoop, the caches on its local processor bus and snoop all caches on the remote processor bus and the I/O bus. The amount of snoop traffic can significantly impact the scalability of the system.

The *ProLiant* 8000 architecture uses cache accelerators to minimize snoop traffic to the remote processor bus and I/O bus. The cache accelerators store the address and state of the data for all caches on their respective buses. The Profusion crossbar switch uses this information to determine whether to snoop the remote processor and I/O buses. Depending on how often a software application shares data, the reduction in snoop traffic can significantly improve overall system performance and scalability.

I/O Filter

The *ProLiant* 8000 server also includes three Compaq host-to-PCI bridges with prefetch buffers, so they act as caching bridges. The Profusion chipset contains a built-in I/O filter for the caching bridges on the I/O bus. The I/O filter enhances performance by reducing snoop traffic on the I/O bus. This I/O filter is designed to work with all three of the Compaq host-to-PCI bridges. When a processor requests a cache line with the intent to modify it, the MAC performs a lookup into the I/O filter to determine if that line resides in one of tbe caching bridges. If it does reside there, the MAC initiates a transaction on tbe I/O bus to invalidate that cacbe line. If the cacbe line is not present in one of the bridges, then no transaction is run on the bus.

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Compaq Host-to-PCI Bridges

The Compaq host-to-PCI bridges included in the *ProLiant* 8000 server were engineered to enhance performance of the Profusion chipset. Tbey include the following features:

- 64-bit, 66-MHz PCI support with a theoretical peak throughput of 533 MB/s
- Delayed transaction support
- Asynchronous design to accommodate multiple bus frequencies
- Multiple prefetch buffers
- PCI Hot Plug technology
- Peer-to-peer transaction support

64-Bit, 66-MHz PCI Support

Compaq licensed the host-to-PCI bridges to Intel, and they will ship with a Compaq logo on top in servers produced by other original equipment manufacturers. The bridges are compliant with the PCI 2.2 Specification[1] and support 64-bit, 66-MHz PCI transactions.

The *ProLiant* 8000 server supports three bridges with up to eleven I/O expansion slots. PCI Bus 1 operates at 33 MHz and includes one 32-bit PCI Hot Plug slot and three 64-bit PCI Hot Plug slots. PCI Bus 2 is also a 33-MHz bus and includes five 64-bit PCI Hot Plug slots. PCI Bus 3 operates at 66 MHz with two 64-bit PCI Hot Plug slots.

The Compaq 8-way architecture will support up to four Compaq host-to-PCI bridges. However, by incorporating only three bost-to-PCI bridges, the *ProLiant* 8000 server has room on the I/O board to deliver an additional PCI slot, a meaningful advantage for enterprise customers who consistently request additional capacity.

Delayed Transactions

One of the most important features of Compaq's host-to-PCI bridge is that it supports delayed PCI transactions, which improve bus performance. In a delayed PCI transaction, the device that initiates the transaction polls the host-to-PCI bridge to determine if the requested data is there, rather than holding the bus while waiting for the data. This allows other devices to use the bus while the transaction is completed. To further improve bus efficiency, Compaq built in additional features to reduce the amount of polling.

Asynchronous Design

The bridge is split into two sections: upstream (bost I/O side) and downstream (PCI side). All the functions on the upstream side are in the host processor clock domain at 100 MHz. All functions on tbe downstream side are in the PCI clock domain at up to 66 MHz. This asynchronous design is a flexible solution for supporting multiple clock speeds.

Multiple Prefetch Buffers

The Compaq host-to-PCI bridge is designed with multiple prefetch buffers to ensure optimum I/O-to-processor performance. Each buffer can hold multiple cache lines. These buffers are sized to provide optimal performance at a reasonable and cost-effective die size. Because of the delayed transaction support, the bridge can get data for multiple PCI devices concurrently. Other controllers can hold only a single cache line and a single request at a time.

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[1] *PCI Local Bus Specification*, Revision 2.2, announced January 25, 1999, PCI Special Interest Group.

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PCI Hot Plug Technology

The host-to-PCI bridges include electronics to support PCI Hot Plug technology, which was pioneered by Compaq. PCI Hot Plug technology provides the ability to remove, replace, upgrade, and add PCI adapters without shutting down the server. Any PCI adapter can be placed in a PCI Hot Plug slot; bowever, PCI Hot Plug device drivers and OS support are required to enable PCI Hot Plug functionality.

Peer-to-Peer Transactions

The host-to-PCI bridges also support PCI peer-to-peer transactions. They allow communications between two devices on the same PCI bus segment. They also allow communication across the I/O bus between PCI devices on different PCI bus segments (Figure 4).

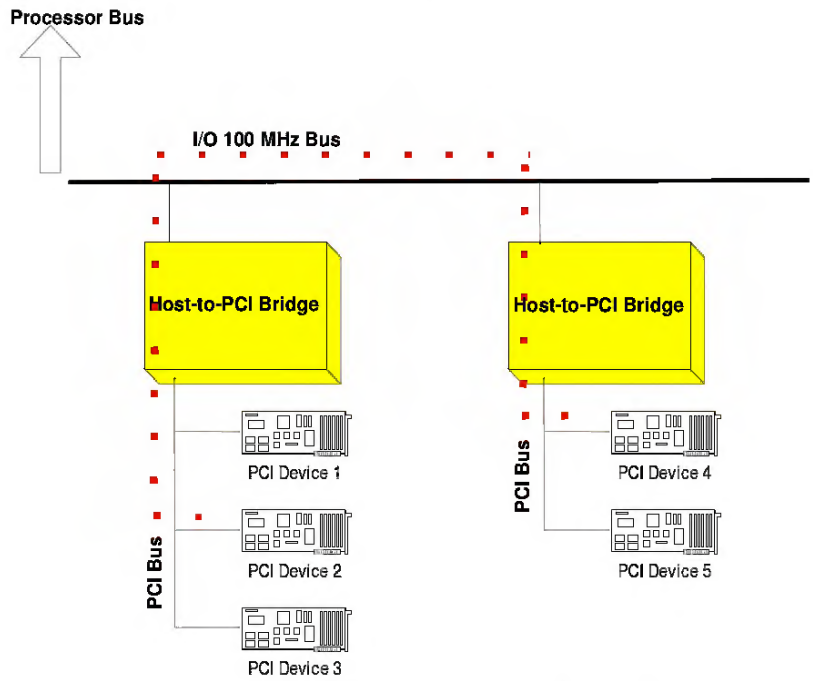

Figure 4: Schematic of peer-to-peer communications between PCI devices on different I/O bus segments.

Microprocessors embedded in the PCI devices make these devices "intelligent" and perform the communication tasks otherwise handled by the processors. Thus, the host-to-PCI bridges enhance performance by freeing the system processors to do other work.

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Pentium III Xeon Processor Technology

The Pentium III Xeon processor is based on tbe Pentium II Xeon processor cartridge form factor. The Pentium III Xeon processor provides a higher internal core frequency than the Pentium II Xeon processor and includes 70 new streaming instructions tbat permit more efficient use of memory above 4 GB. The Pentium III Xeon processor includes the following features:

- Minimum 550-MHz core frequency
- 330-contact slot connector form factor (formerly called Slot 2)
- Full-speed cacbe on module
- 512-KB (550-MHz only), 1-MB, or 2-MB Level 2 (L2) cache
- Katmai core logic

Level 2 Cache

Each Pentium III Xeon processor includes an L2 cache sized at 512 KB, 1 MB, or 2 MB that operates on a full-speed backside bus. The large cache size and full-speed backside bus enable very efficient access to the most frequently used data. This reduces traffic on the bost bus and notably enhances performance.

Katmai Core Logic

Aside from speed and cache size increases, the main difference between the Pentium II Xeon and Pentium III Xeon processors is the migration to the Katmai core logic. The Katmai core logic adds the following enhancements to the existing Intel core:

- Memory streaming
- Concurrent Single Instruction Multiple Data – Floating Point (SIMD-FP)
- Katmai New Instructions (KNI)

Memory Streaming

Memory streaming is a set of techniques that increase tbe utilization of the memory bus during memory reads and writes. Processors must frequently wait for data not stored in cache memory to be retrieved from system memory. Because the system bus connecting the memory to the processor is slower than the processor core speed, this results in a performance bottleneck. Katmai's memory streaming enables the processor to prefetch data from system memory to cache memory.

During writes to memory, other new instructions can tell the processor to bypass the L2 cache and write data directly back to memory. Bypassing the L2 cache frees room in the cache for more data. This technique is useful when the software programmer knows in advance that tbe data will not be requested again in the near future.

Concurrent SIMD-FP

Concurrent SIMD-FP applies the same architecture used by MMX for integer operations to floating-point numbers. Floating-point numbers are used extensively in 3D graphics and scientific computations. Katmai processors have eight new registers that can each hold four single-precision floating-point numbers. Once the registers are filled, a single instruction can be used to add, subtract, or do other operations between the registers. For example, eight floating-point numbers could be added together using one instruction call.

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Katmai New Instructions

KNI refers to tbe addition of 70 new instructions to the MMX instruction set. Tbe new instructions primarily refer to the new SIMD-FP registers, but some new integer instructions also have been added. Tbe new instructions are particularly useful for multimedia applications such as 3D rendering and video encoding and decoding.

HIGH-AVAILABILITY TECHNOLOGIES

Tolerance of server downtime continues to decrease, as companies become more global, decentralized, and aware of downtime costs. The *ProLiant* 8000 server answers the demand for high availability by incorporating the following features into the server hardware:

- PCI Hot Plug technology
- Redundant array controller technology
- Redundant network interface controller (NIC) technology
- Redundant, hot-plug fans
- Redundant PPMs
- Redundant, hot-plug power supplies
- Hot-plug drives

Redundant components help ensure that the server is highly fault tolerant. In redundant configurations, if a power supply, fan, or PPM fails, the redundant standby component can take over operation with no downtime to the server. With the addition of hot-plug capabilities, server downtime can be eliminated while components are being replaced, added, or upgraded.

PCI Hot Plug Technology

The *Compaq ProLiant* 8000 server incorporates industry-standard PCI Hot Plug technology. This technology, pioneered by Compaq, adds hot-plug capabilities to existing PCI adapters for increased system availability and serviceability. Compaq led the industry by licensing its PCI Hot Plug implementation to Intel, thus broadening customer access to this industry-standard technology.

Compaq's implementation of PCI Hot Plug incorporates electronics into the server to control each PCI Hot Plug slot individually, so that a single slot can be powered down without affecting the operation of the other slots. Compaq's implementation of tbe PCI Hot Plug standard allows the following capabilities while the system is running:

- *Hot replacement* – replacing a single PCI adapter with a similar adapter
- *Hot upgrade* – replacing a PCI adapter with an upgraded adapter
- *Hot expansion* – adding a PCI adapter to an empty slot

The *ProLiant* 8000 server supports all three hot-plug capabilities for all 64-bit and 32-bit PCI Hot Plug slots. These capabilities can be added incrementally, depending on the OS implementation.

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For more information about major OS vendors that support PCI Hot Plug, refer to the following Compaq technology briefs:

- *PCI Hot Plug Technology*, document number ECG080/0698
- *PCI Hot Plug Technology with Novell Architecture*, document number ECG081/0698
- *PCI Hot Plug Technology with SCO Software Architecture*, document number ECG082/0698
- *PCI Hot Plug Technology with Microsoft Windows Architecture*, document number ECG071/0399

Redundant Array Controller Technology

The *ProLiant* 8000 server supports up to two *Compaq Smart* Array 4250ES controllers in a redundant configuration. The *Smart* Array 4250ES controller is specially designed for use in the *ProLiant* 8000 server. See "Storage Technologies" for more information on the array controller technology in the *ProLiant* 8000 server.

Smart Array 4250ES controllers may be used in PCI connectors 10 and 11. These connectors attach the 64-bit PCI bus and four Wide Ultra-3 SCSI buses to the *Smart* Array 4250ES controllers. All five buses are common to botb connectors, and thus common to both controllers. Three of the SCSI buses are routed to SCSI connectors on the I/O board. Cables are preinstalled from these three SCSI connectors to the three SCSI drive cages. The fourth SCSI bus serves as a link between the two controllers. This link allows two *Smart* Array 4250ES controllers to be easily installed in the *ProLiant* 8000 server to provide controller redundancy. The Smart Array 4250ES controller is a Wide Ultra SCSI device so the internal drive cages and the Wide Ultra-3 SCSI buses will run in Wide Ultra SCSI mode.

The two controllers monitor each other's status and maintain cacbe coherency between them. Botb controllers (the primary and secondary controller) are attached to the same drives in an active-standby mode. If the primary controller fails, tbe secondary controller immediately assumes command of the drive array with no interruption of server operation or loss of data. PCI Hot Plug technology allows a failed controller to be replaced without rebooting the server.

The SCSI subsystem uses a simplified cable design that allows the drive cages to be connected directly to the I/O board. The design eliminates cumbersome loop-back cables while allowing cable-free redundancy and hot-plug capability.

Redundant Network Interface Controller Technology

Compaq's redundant Netelligent NIC technology allows two similar NICs to share a single instance of device driver code. One NIC becomes the active network controller and the otber NIC acts as a standby controller. If the active NIC fails, the network traffic is automatically switched to the standby NIC. This redundancy eliminates the NIC or cable as a single point of failure. With PCI Hot Plug technology, tbe failed NIC can be replaced without rebooting the system. Thus, tbe end user can have continuous service and the administrator can greatly reduce planned and unplanned downtime.

The *ProLiant* 8000 server supports a Compaq NC3131 Fast Ethernet controller on the PCI local bus. The NIC bas two ports for 10BaseT or 100TX Ethernet. The ports are seen as two separate local area networks, both supporting full-duplex Ethernet (20 Mb/s) and Fast Ethernet (200 Mb/s). Redundancy is available across the two ports with one NIC. In addition, the NIC is upgradeable with a daughter card to an additional two ports of 100BaseTX Ethernet, a single port of 100 BaseFX, or single-port Gigabit Ethernet SX or LX Fiber support. Redundancy is also available here; the NIC can be configured to failover from the Gigabit daughter card to the dual 10/100 ports in the event of a failure, thus allowing continued access to the network.

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Redundant Hot-Plug Fans

The *ProLiant* 8000 server has four primary hot-plug fans (external) and four redundant fans (internal) for the processor and memory section. The rear pair of primary hot-plug fans for the processor and memory section is enclosed in a single fan unit (Figure 5). This unit can be easily removed by means of a single thumbscrew. The front pair of primary hot-plug fans is enclosed in another single fan unit (Figure 6), which can be easily removed by means of a latch. The primary hot-plug fans spin under rotor control while the internal, redundant fans spin freely in the server airflow because they are not required for cooling. If the primary fan unit fails, the redundant fans will start automatically. The hot-plug light-emitting diodes (LEDs) indicate the status of the fans: green indicates the fans are functioning properly, and amber indicates the fans have failed.

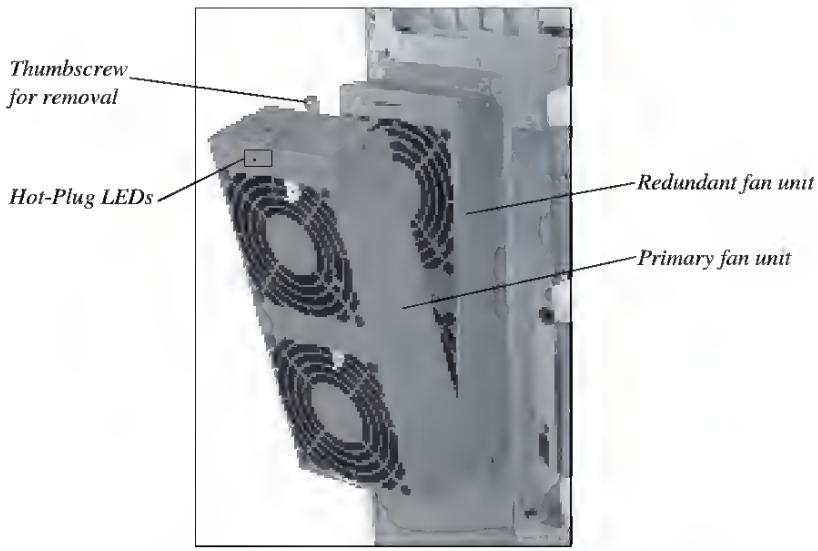

Figure 5: Rear hot-plug fans for the processor and memory section of the ProLiant *8000 server.*

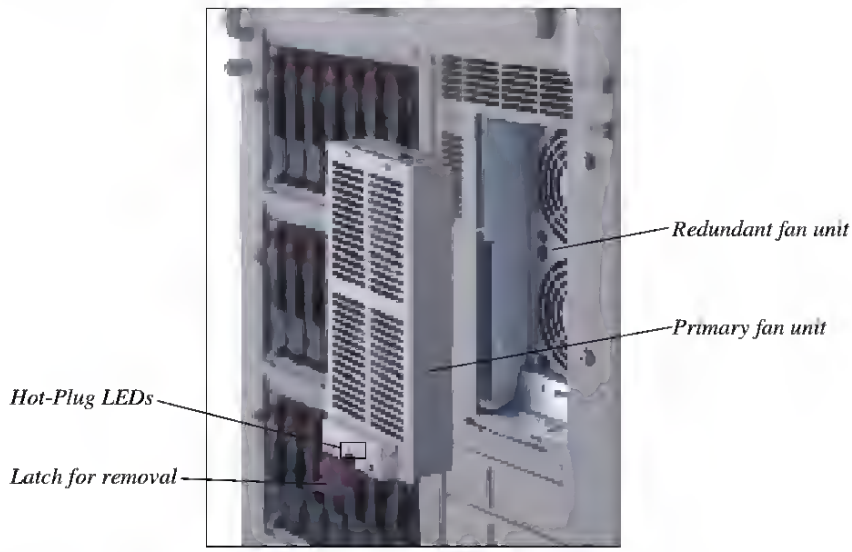

Figure 6: Front hot-plug fans for the processor and memory section of the ProLiant *8000 server.*

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The server also has two hot-plug fans for the I/O board in the upper section of the server (Figure 7). Only one operating fan is needed to cool the I/O hoard. The other fan provides redundancy. If the operating fan should fail, the other fan would start automatically and continue cooling the I/O board. When the failed fan is replaced, redundancy is restored.

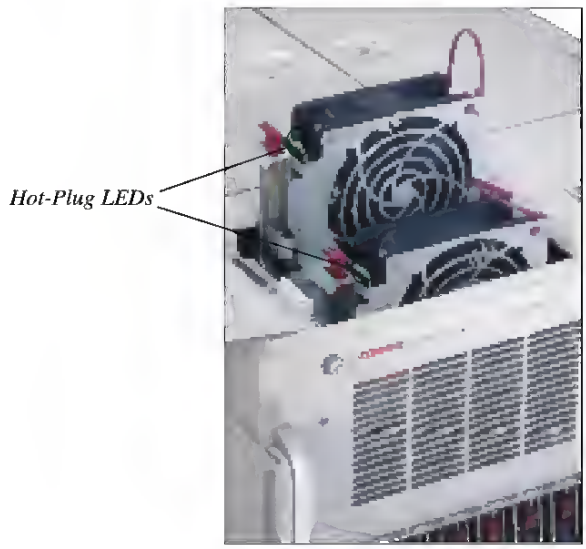

Figure 7: Hot-plug fans for the I/O section in the ProLiant *8000 server.*

The fan control logic operates independently from the system processor and OS. Regardless of which OS is running or its condition, the fan control logic and the server temperature monitoring circuitry work together to cool the server effectively.

The fans have two speeds: normal and high. Under typical operating conditions, the normal fan speed is sufficient to cool up to 8 processors, 21 hard disk drives, and 11 I/O expansion boards. As a precaution against increases in ambient air or localized internal temperatures, Compaq established three thermal trip points, as shown in Figure 8. If the first thermal trip point is reached, the fans adjust automatically to high speed to increase cooling.

Users can select whether to enable a server response to the second thermal trip point. When enabled, if the internal air temperature exceeds the second trip point, the OS initiates a controlled shutdown of the server. Simultaneously, a warning message is sent to the Integrated Management Display (IMD) and Compaq Insight Manager. The server restarts automatically when it has cooled sufficiently.

Finally, in the unlikely event server temperature continues to rise, a third trip point shuts down the power supplies to protect critical components from overheating. The server restarts automatically when it has cooled sufficiently.

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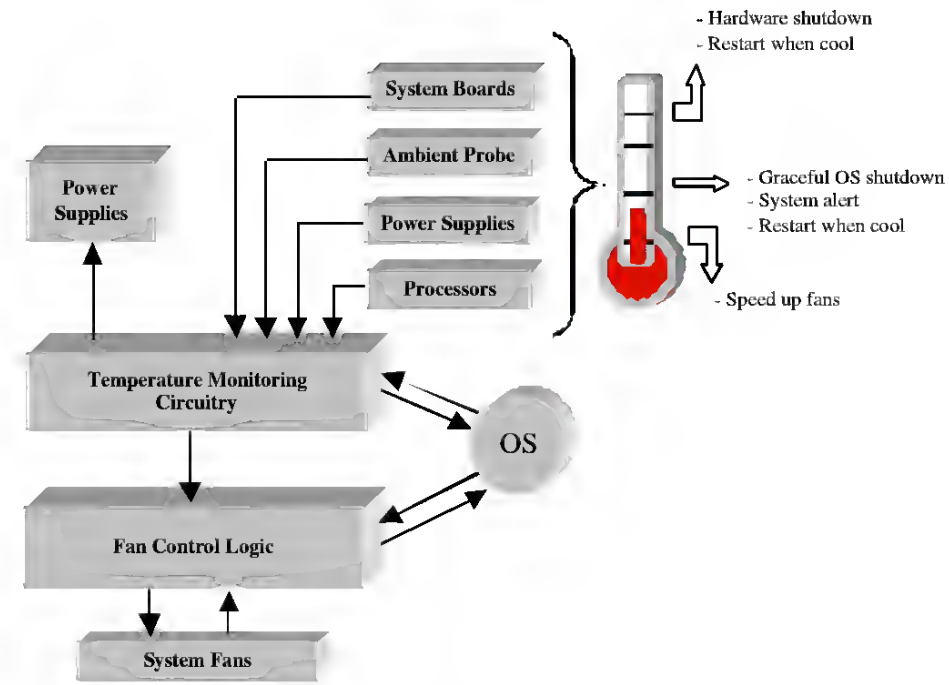

Figure 8: Schematic diagram of fan control logic.

Redundant Processor Power Modules

Each processor in the *ProLiant* 8000 server has its own redundant PPM. An additional PPM is included in tbe server to power the system board. PPMs are also known as voltage regulator modules. The PPMs deliver the precise voltage required by the processors.

Compaq PPMs are programmable and support all current and future versions of Xeon processors. Each PPM has redundant circuitry. If a failure occurs in one circuit of the module, the other circuit automatically takes over the task of regulating power to the processor.

Redundant Hot-Plug Power Supplies

The *ProLiant* 8000 server uses one of the newest Compaq technologies to reduce downtime: intelligent, redundant, hot-plug power supplies. The server ships standard with two dual-rated 1150-watt/500-watt power supplies and supports three power supplies for an N+1 redundant configuration. The power supplies are connected to a separate power backplane in the server and include new handles for easier insertion and removal. If one of the power supplies fails, its internal fans will continue to operate and help cool the server.

The power supply has an embedded microcontroller and an inter-integrated circuit bus that communicates the status back to the system health drivers.[2] The health drivers then send status information to the IMD and to Compaq Insight Manager.

[2] For additional details about Compaq's intelligent power supplies, see the technology brief *Intelligent Power Supply Technology*, document number ECG016/0198.

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The microcontroller performs the following functions:

- **Self-test.** The intelligent power supplies perform their own power-on self-test (POST) that checks temperature, RAM integrity, ROM version, analog-to-digital conversion accuracy, and nonvolatile memory integrity of the power supply.
- **Auto Line Sensing.** Because the power supplies are rated for both 1150 watts (at 220 volts) and 500 watts (at 110 volts), a line-sensing feature automatically recognizes which line voltage is connected. The customer does not need to configure the supply for voltage.
- **LED Standby Controls.** The microcontroller also drives two status LEDs on the back of the power supply that indicate power status, as shown in Figure 9. This gives the user vital status information at a glance.

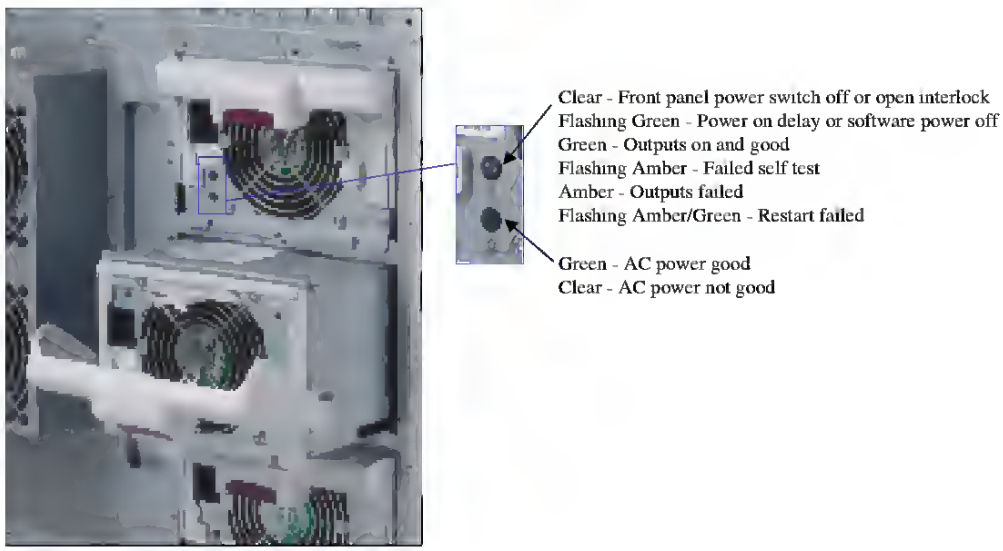
Clear - Front panel power switch off or open interlock
Flashing Green - Power on delay or software power off
Green - Outputs on and good
Flashing Amber - Failed self test
Amber - Outputs failed
Flashing Amber/Green - Restart failed
Green - AC power good
Clear - AC power not good

Figure 9: Power supply LED status indicators.

Power-Down Controls

As shown in Figure 10, the server power switch connects to the Advanced Configuration and Power Interface (ACPI) controller rather than directly to the power line. This means that turning off the power switch does not turn off power instantly. Instead, the ACPI controller communicates with the system board and the OS. The power-down controls can be configured in one of three ways:

- Secure mode – Power supply will not shut down if power switch is pressed.
- Delay mode – Power supply will shut down after a 10-second delay. This allows time to reactivate the switch if it was mistakenly pressed.
- Graceful shut down – A 10-second delay counter begins as a message warning of an imminent power-down goes to Compaq Insight Manager and the IMD. Because of the communication between the ACPI controller and the OS, the OS can delay the power down until all running applications have properly closed. Should the OS not be running, the power would go down when the delay counter expired.

The power-down control feature is supported under Microsoft Windows NT and Novell NetWare. SCO is planning to implement support for the power-down control in the future.

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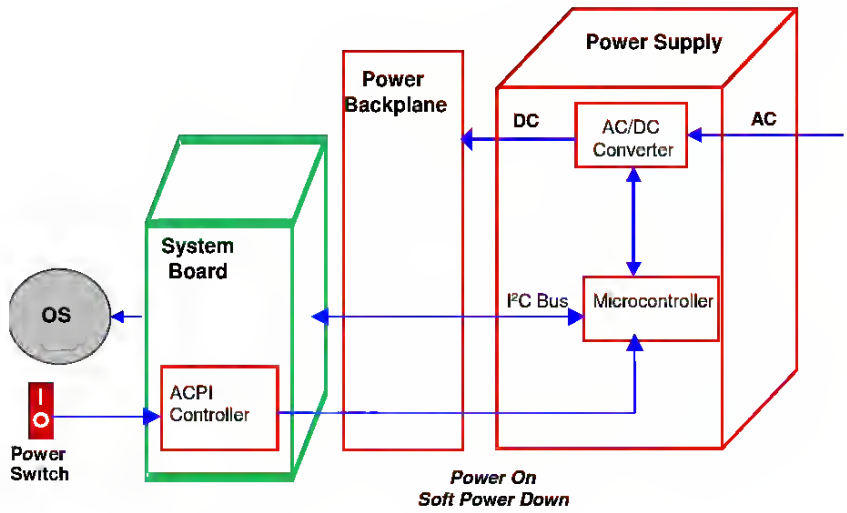

Figure 10. Power supply schematic.

Load Balancing

The power supplies automatically load balance to within 10 percent of the average current of all supplies. Before the power comes up, the master power supply matches its output load rails to those of the other power supplies so that the load is automatically balanced across all power supplies. If one supply fails, the load balancing feature allows the other supplies to pick up the remaining power load quickly.

Power Factor Correction

Compaq's intelligent power supplies have built-in power factor correction to synchronize the voltage and current phases. This helps ensure that maximum power is available. It also reduces the return current in the ground line, which reduces the overall power consumption.

Hot-Plug Capability

When a power supply is hot swapped, the microcontroller governs the power-up and power-down sequences, enables the health drivers to calculate redundancy "on the fly," and informs the health drivers of changes in load. Compaq hot-plug power supplies are readily identifiable by their port-colored bezel, as shown in Figure 11.

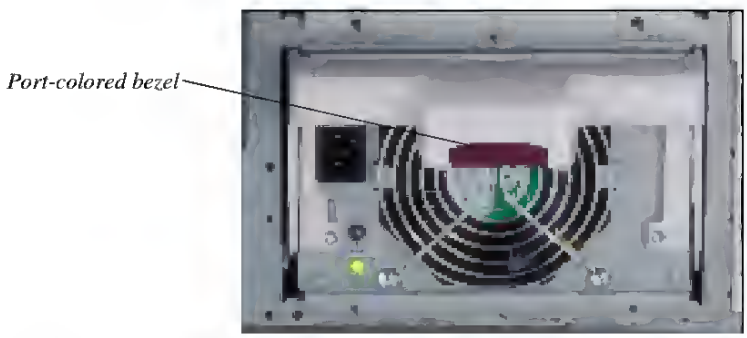

Figure 11: Front view of hot-plug power supply with port-colored bezel.

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Hot-Plug Hard Disk Drives

The *ProLiant* 8000 supports up to three Wide Ultra-3 SCSI internal drive cages. Each *ProLiant* 8000 internal drive cage can support a maximum of seven 1-inch hot-plug drives (for a total of 21 drives with all three drive cages installed). When the server is configured for maximum capacity, it can support 382 GB of internal storage. Capacity will increase in the future as new drive technologies emerge.

STORAGE TECHNOLOGIES

As corporations commit more critical information to computers, the requirements for more storage capacity and faster data movement are increasing at a startling rate. The *Compaq ProLiant* 8000 server includes new storage technologies that help meet these requirements. New hard drive technology and a specially designed array controller allow the *ProLiant* 8000 server to deliver the highest levels of internal storage capacity faster and with more reliability.

Hard Drive Technology

The *Compaq ProLiant* 8000 server uses low-voltage differential (LVD) Ultra-3 SCSI hard drives. These new one-inch drives allow the *ProLiant* 8000 server to support 21 total drives—three drive cages with seven hard drives each—for a maximum internal storage capacity of 382 GB of data.

Ultra-3 SCSI hard drives use a 16-bit bus and a double pumped 40-MHz clock rate to achieve maximum transfer rates of 160 MB/s. This bus speed provides the performance demanded by today's data-intensive applications and prevents system performance from becoming I/O limited as drive throughputs increase.

Although the *ProLiant* 8000 server supports Wide Ultra-3 SCSI hard drives, the internal drive cages and the Wide Ultra-3 SCSI buses will run in Wide Ultra SCSI mode with the Smart Array 4250ES controller, which is a Wide Ultra SCSI device.

Array Controller Technology

The *ProLiant* 8000 server supports up to two *Compaq Smart* Array 4250ES controllers—providing high-performance and ease-of-use features. The *Smart* Array 4250ES controller offers three Wide Ultra SCSI channels, allowing a single controller to support all three internal hot-plug hard drive cages in the new *ProLiant* 8000 server. Since all three drive cages run off the same RAID engine, all 21 internal hot-plug hard drives can be configured as one massive 382-GB array or multiple smaller arrays.

RAID – Redundant Array of Independent Disks

Additionally, the *Smart* Array 4250ES controller uses a 64-bit PCI Hot Plug extended SCSI connector and a cable-less design that is optimized for the *ProLiant* 8000 server. The extended SCSI connector gives customers the flexibility to accommodate both 64-bit and 32-bit technology. The cable-less design allows the hard drive cages to be directly connected to the I/O board itself, not the array controller. This means much easier PCI Hot Plug usage and the elimination of cumbersome loop-back cables.

The *Smart* Array 4250ES controller supports RAID levels 0, 0+1, 1, 4, and 5. In addition, the controller uses a Compaq developed RAID 5 engine that optimizes RAID 5 performance. The controller also supports online spares, which improves overall system fault tolerance by automatically replacing a failed drive and quickly restoring the system to full RAID protection.

The *Smart* Array 4250ES controller includes a robust 64 MB of battery-backed read/write cache. Rechargeable batteries are integrated into the cache, which is actually a removable card installed onto the Smart Array 4250ES controller base card. The removable DRAM and batteries keep posted-write data secure in the unlikely event that the base controller board should fail. If a system

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power outage occurs while write data is stored in the cache, the data will be protected for at least four days on power supplied by the battery backup system. If the base controller board should fail, the cache board can be installed on a replacement base card. Once system power is returned, the posted write data is automatically written to disk.

MANAGEMENT TECHNOLOGIES

Fault-tolerant, redundant features are only part of what makes Compaq servers highly available. Compaq offers a range of hardware- and software-based server management tools that can be used to reduce downtime and increase productivity. The *ProLiant* 8000 server includes the following standard tools available to all Compaq servers:

- **Automatic Server Recovery.** ASR automatically resets tbe server after a critical hardware or software error. ASR can reset the server to the OS or to the System Partition Utilities. The ASR reset function is based on a hardware timer working in conjunction with the Server Health Drivers. If the Server Health Drivers can no longer reset the hardware timer after some user-specified amount of time, tbe server is automatically reset. ASR can also be configured to page the administrator when an ASR event occurs.
- **System Partition Utilities.** These utilities assist the system administrator in diagnosing server problems, configuring new bardware, and upgrading ROMs. For example, an administrator can analyze the system configuration files to verify tbat no interrupts or other conflicts are causing system failures. The System Partition Utilities are available when the server is reset. ASR can be configured to reset automatically to the System Partition Utilities; or the administrator can reboot to the System Partition Utilities through Compaq Insight Manager.
- **Compaq Insight Manager.** This software-based management tool monitors more than 1,000 management parameters to allow fault prediction and alerting, asset and configuration inventory, and performance monitoring. Through Compaq Insight Manager, a remote administrator can request an OS console operation, reset the server, view utilities, and view system configuration information. See the white paper *Compaq Insight Manager,* document number 11CW-1199A-WWEN, for more details.
- **Asynchronous Insight Management.** Asynchronous Insight Management provides access to Compaq Insight Manager through a dial-up networking, or asynchronous, connection. This gives an administrator additional flexibility in troubleshooting problems. If the server OS is still functioning, an administrator can dial in remotely and access Insigbt Manager througb a point-to-point protocol (PPP) connection.

In addition to these utilities, the *ProLiant* 8000 server also ships standard with additional management technologies that reduce downtime and increase productivity even more. Remote-flash Redundant ROM allows administrators to update tbe ROM remotely, and the auto-default ROM configuration provides default configuration settings for most devices. The IMD and Integrated Remote Console (IRC) provide essential information at a glance and allow users easy remote access to their servers. For additional remote management functionality, customers can request that the optional Remote Insight Board/PCI be added to the *ProLiant* 8000 server.

Remote-Flash Redundant ROM

The *ProLiant* 8000 server is equipped with a Remote-flash Redundant ROM that improves manageability. Using the Compaq Remote ROM Flash Utility, administrators can flash tbe system ROMs for a wide range of Compaq servers, locally or across the network. The Remote ROM Flash Utility is a combination of components that allows administrators to upgrade the system ROMs on servers from a single point of execution. The ROM upgrades can either be flashed individually or

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batched together to perform multiple ROM upgrades in a single step. The following components are used in the ROM flash process:

- **User interface.** The user interface is command-line driven and allows administrators to tailor functionality to a specific environment.
- **System ROM Flash Service.** The System ROM Flash Service allows the user interface to perform essential functionality on remote servers for the ROM upgrade process, including remote system shutdown, mounting, and unmounting the system partition.
- **Compaq System Configuration Utility.** The latest version of the Compaq System Configuration Utility is integrated within the Compaq Remote ROM Flash Utility. Parts of this utility have heen enhanced to allow flawless firmwarc upgrades.
- **ROMPAQ Utility and image files.** Generally, any version of the ROMPaq Utility and image files can be used. The latest ROMPaq Utility and images are available from the Compaq website at http://www.compaq.com/support/files/server/us/index.html. It is possible to maintain a common collection of ROM images in a particular directory on the local administrative client or on a shared resource.

All of these components work together to deliver an easy-to-manage solution for administrators who need to manage large-scale ROM upgrades, like those required for a year 2000 update, or a few ROM upgrades at a time.

Compaq Remote-flash Redundant ROM provides a unique redundancy feature that helps ensure system availability. During the ROM flash process, it is possible for a prohlem to occur. Typically, a failure during the ROM flash would shut down the server and require the administrator to replace the ROM. This could he a significant problem if, for example, the flash were scheduled for a time when the administrator was unavailahle. Theoretically, the server could be down for hours until the administrator became available to manage the situation. Compaq's unique redundancy feature helps ensure system availability because it gives the system the ability to recover the last known good system ROM in the event that the current system ROM is corrupted.

When a *ProLiant* 8000 server leaves the factory, both system ROMs contain the same image. Through subsequent boots of the server, if integrity errors are detected by the boot block, the system will automatically launch the redundant image and continue the POST process. If the redundant ROM is launched, the user will see an error message identifying the faulty system ROM.

Auto-Default ROM Configuration

When a *ProLiant* 8000 server is first powered on, the system ROM detects the unconfigured state of the hardware and provides default configuration settings for most devices. By providing this initialization, the system can run *Diagnostics* and other software applications before running the normal *SmartStart* and *System Configuration* applications.

If the user inserts a *System Configuration*, *Diagnostics*, or *SmartStart* CD in the CD-ROM drive before powering on the server, the system ROM will hoot using that CD. If the system ROM does not detect one of these CDs, the user will be prompted for the intended OS. The system will reboot if any OS-dependent configurations have changed with the new OS selection. If the selected OS-dependent configurations match the current configurations, the system will hoot normally. The OS selection may be changed during subsequent reboots.

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Integrated Management Display

The IMD (Figure 12) is a backlit liquid crystal display that allows administrators to enter server and contact information. Just as importantly, the IMD displays critical information, warning messages, and error messages in an easy-to-understand format.

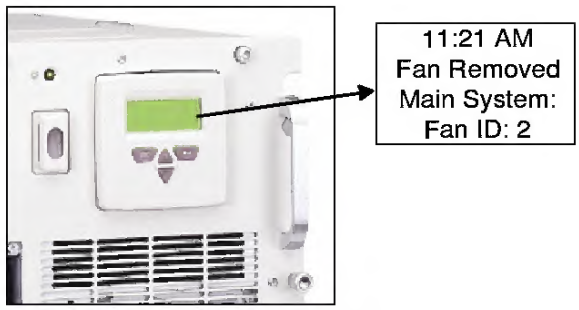

Figure 12: Integrated Management Display with sample alert message.

A 5-volt auxiliary power line supplies power to the IMD whenever the server power line is plugged in. Even if the server power goes down, the auxiliary line continues to power tbe IMD so that critical information, such as the last error message and the administrator's name, can be obtained.

The IMD unit contains its own static memory. This memory contains the software code to control the IMD and the text messages shown on the display. All software enhancements added in the future will be available througb a flasbable ROMPaq. During POST, all event logs, system information, and administrator information are uploaded from the system nonvolatile RAM. During runtime, new events are stored in the nonvolatile RAM and the IMD SRAM. If the IMD unit is removed and replaced, all key event and system information is still available.

Integrated Remote Console

IRC consists of a Compaq designed ASIC and associated firmware. IRC allows out-of-band, or asynchronous, management capabilities sucb as remote console and remote reset. These capabilities are independent of the state of the network OS. With IRC, an administrator has full text mode video and keyboard access to access the server, perform diagnostics, reset the system, watch the reset process remotely, and view reset sequences, regardless of whether the OS is functional.

For more information about IRC, refer to the Compaq technology brief *Remote Server Management with Integrated Remote Console*, document number 582A/1096.

Remote Insight Board/PCI Option

The optional Remote Insight Board/PCI provides seamless remote access and control independent of both the server OS and the server hardware. The Remote Insight Board/PCI is also fully integrated witb Compaq Insigbt Manager. An administrator can remotely access tbe Remote Insight menu through the Insight Manager interface or through a web browser. The web browser uses the PPP dial-in connection with its user authentication and security features or a TCP/IP connection, rather than an unsecured Internet web connection.

TCP/IP – transmission control protocol/internet protocol

Like IRC, the Remote Insight Board/PCI can be used when the server OS is not functioning. Unlike IRC, Remote Insight can be used even when the server hardware is not functioning or power is lost. If a server power loss occurs, Remote Insight's battery backup provides power for at least 30 minutes—long enougb to send out power-down alerts.

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Remote Insight provides several important troubleshooting features that none of the other Compaq tools can. Remote Insight provides both numeric and alphanumeric paging. Other essential troubleshooting features are provided by Remote Insight througb its multiple diagnostic capabilities. It captures videotext of the last two reset sequences in addition to the last failure sequence. It can also access several management logs that are unavailable through IRC. For additional information about the Remote Insight Board/PCI, see the white paper *Compaq Remote Insight Board/PCI: Hardware and Software Architecture,* document number ECG072/0798.

SERVICEABILITY FEATURES

By providing easy access to server components, the *ProLiant* 8000 server design further reduces the downtime associated with upgrades and field maintenance.

The hot-plug fans and power supplies are easily accessed without removing the server side or top panels, and the side and top panels release quickly through the use of three thumbscrews. The processor board, memory boards, and the I/O board are mounted using lever-actuated quick-release modules. In addition, the processor and I/O boards are separated in the chassis so that each can be replaced independently (Figure 13).

The I/O board is located in the top of the cbassis to allow easy access for adding or replacing PCI boards. This is an important convenience for using the hot-plug slots.

The internal drive cages are separated into three units. Each drive cage unit can be removed by sliding it out from the front of the server. This allows easy replacement of hot-plug drives as the customer upgrades to next-generation drive technology.

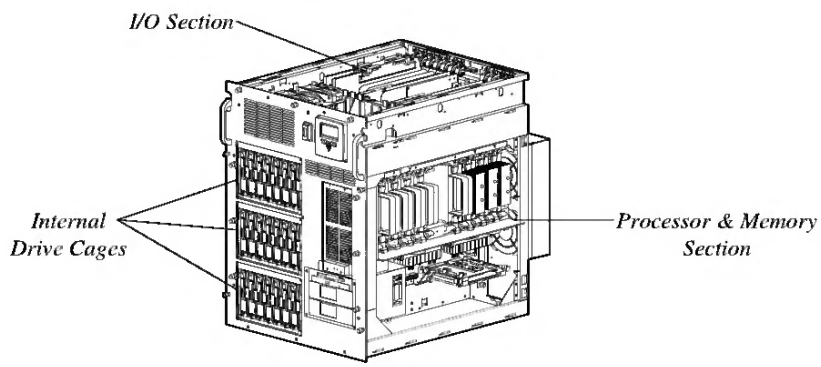

Figure 13: ProLiant *8000 chassis, front view.*

CONCLUSION

The *Compaq ProLiant* 8000 server offers customers a high-performance, highly scalable solution for their data center needs. The server also provides all the high-availability features customers have come to expect from Compaq servers. In addition, Compaq has integrated key management technologies and serviceability features that further reduce downtime and improve manageability.

For customers needing greater performance, availability, and scalability in the data center, the *ProLiant* 8000 server is an excellent choice. Development of this server demonstrates Compaq's commitment to provide industry-standard servers that exceed customer expectations. As business requirements become more demanding, Compaq will continue to deliver servers that meet those requirements and can be expanded to meet future needs.

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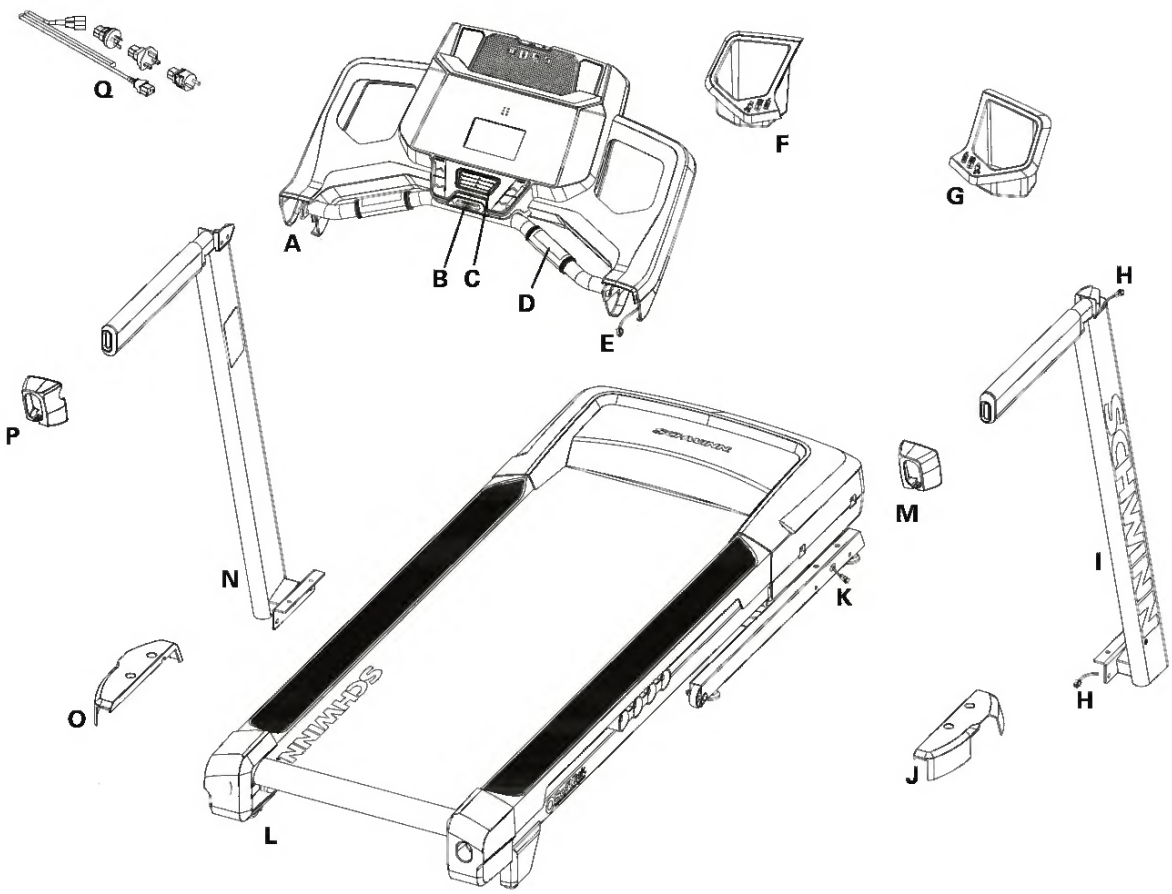

A	Console Assembly	G	Tray, Right	M	Handlebar Shroud, Right
B	Safety Key Port	H	Right Upright Cable	N	Upright, Left
C	Fan	I	Upright, Right	O	Base Shroud, Left
D	Contact Heart Rate Sensor	J	Base Shroud, Right	P	Handlebar Shroud, Left
E	Console Cable	K	Base Cable	Q	Power Cord
F	Tray, Left	L	Base Assembly		

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